Poster

ON THE LATTICE PARAMETER AND HEIGHT PROFILES IN THE STRANSKI-KRASTANOV GROWTH MODE

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One of the most characteristic features of the Stranski-Krastanov (S-K) growth mode in low-dimensional heterostructures is to obtain distributions of semiconductor quantum dots (QDs) nearly homogeneous in their shapes and sizes. The uniformity of sizes and shapes could allow the fulfilment of optoelectronic devices with appropriate quality.
It is generally understood that the main mechanism of the formation of QDs in thin solid films on solid substrates is the Asaro-Tiller-Grinfeld instability that releases epitaxial elastic stresses in the film caused by the crystal lattice mismatch between the film and the substrate [1]. The faceting instability of a thermodynamically unstable surface is another mechanism that can also play an important role in the formation of surface structures during epitaxial growth [2]. Both mechanisms lead to the formation of mounds that usually coarsen, with larger islands growing at the expense of the smaller ones. In the coarsening process, the balance between the surface and elastic energies can lead to the formation of uniform-size islands as a preferred configuration having minimal energy. Additionally, mechanisms based on wetting interactions between the film and the substrate can terminate coarsening of the surface structures. Attending to the last mechanism, the boundary-layer and glued wetting-layer models are reported in the literature, where variation of -the surface energy, -misfit or -lattice parameter with the film height is considered [3-5]. Focusing on the lattice parameter variation, several dependences with the film height (coverage) are proposed [5, 6]. Due to the complexity of the above phenomena, it seems convenient to investigate the possible influence between the lattice parameter and the resultant height profile.
Then, the aim of this work is to obtain the lattice parameter and height profiles in typical semiconductor heterostructures like Ge/Si and InAs/GaAs evaluated self-consistently. With the continuum elasticity theory in linear approximation, the minimization of free energy density by Euler-Lagrange method leads to a second order differential equation for the lattice parameter variation, whose coefficients are related to the stiffness constants of the film material and the lateral size of the system. The resolution of this equation yields the lattice parameter dependence with the film coverage. Once the lattice parameter profile is obtained, the Euler-Lagrange method applied again to the free energy density leads to Poisson equation for the height function. The inhomogeneous term in Poisson equation is related to constitutive constants of the heterostructure materials and the coverage film. This term represents the geometrical curvature of the investigated systems. Within the framework of the linear approximation, only one step in the self-consistent scheme

is enough to obtain the solution convergence for both profiles. Throughout all calculations, assumption of isotropic surface energy and small slope approach are considered.

References:

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